Resiliency + Sustainability = High Performance

by Emily Lorenz

The transportation-related construction industry has been sustainably minded for some time now. Owners have required that transportation projects, and bridges in particular, take into account the three pillars of sustainability: economy, ecology, and society. In terms of economy, project teams have always been mindful of budgets, and more-commonly consider life-cycle costs rather than just first costs. When avoiding impact to ecology or the environment, projects must commonly work around sensitive habitats and are careful not to disturb waterways or wetlands. Impacts to the traveling public and safety concerns fall into the realm of societal concerns.

While the transportation industry has been at the forefront of sustainable designs for some time, it is important that it transforms to consider the evolution of sustainable, high-performance design to embrace resiliency. This design trend is gaining momentum in the buildings industry, and its principles transfer well to transportation projects also. This article focuses on the importance of resiliency as it relates to sustainable designs, as well as opportunities for the transportation industry to embrace this design strategy.

The Resiliency-Sustainability Connection

Sustainability is often discussed in terms of impact to the environment. And indeed, one reason that we focus on impact to the environment during design is to limit any negative environmental impacts that may exacerbate climate change. Natural disasters significantly affect our economy, our ecology, and our society. And climate change has the potential to increase the frequency, duration, and intensity of natural disasters. Thus, we need resilient structures that can withstand, and continue to function after, natural and man-made disasters.

At all levels of government, decision makers have reached the conclusion that sustainability and resiliency are interconnected. Many have also realized the importance of designing for resiliency so that their communities can continue to function after a major natural disaster. The U.S. Department of Homeland Security (DHS) is an example of a government entity with an increased interest in the resiliency of bridges. "Because bridges are typically more vulnerable than roadways to damage caused by natural and man-made hazards, they are also of interest to the U.S. DHS."[1]

One tool that has emerged to assist communities in assessing their resilience is the *City Resilience Framework*.[2] Developed by Arup with support from the Rockefeller Foundation, the framework assists cities in understanding the factors that contribute to resiliency. This allows cities to "identify critical areas of weakness, and to identify actions and programs to improve the city's resilience."

Still Ahead of the Curve

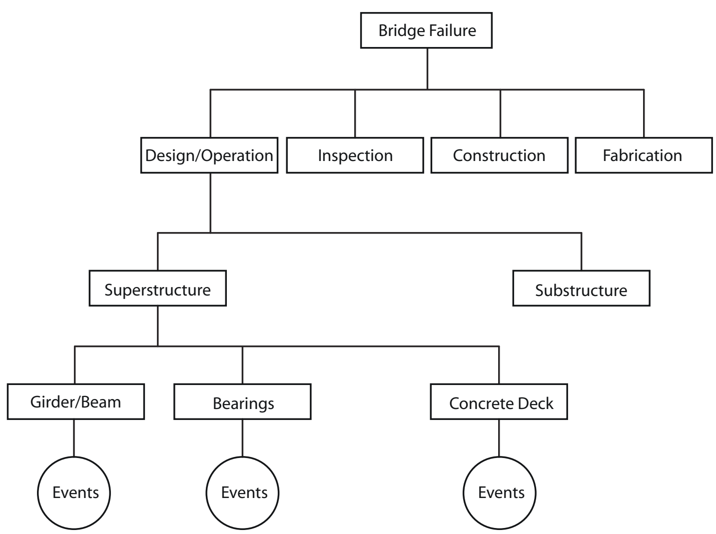
Because highway and transportation agencies have been at the forefront of consideration of sustainable concepts, it is no surprise that the Federal Highway Administration (FHWA) released their *Framework for Improving Resilience of Bridge Design* in 2011.[3] The intent of the framework is to assist designers in

High-performance Structures

According to the *Energy Independence and Security Act* of 2007, the United States government defines a high-performance structure as one that "integrates and optimizes on a life-cycle basis all major high-performance attributes, including:

- energy and water conservation,
- environment,
- safety,
- security,
- durability,
- accessibility,
- cost-benefit,
- productivity,
- sustainability,
- functionality, and
- operational considerations."

Inherent in this definition is that a high-performance structure must consider resiliency. When considering the life-cycle of the structure, one must design to consider major natural or man-made disasters that may impact the structure.



Portion of a fault tree for a typical girder bridge. Diagram: Federal Highway Administration.

achieving more resilient highway bridges.

According to M. Myint Lwin, in his Spring 2012 article in *ASPIRE,*™ "three key factors affect the resilience of highway bridges: ductility, redundancy, and operational importance."[4] When these concepts are applied to the design of a bridge, they allow bridges to better withstand extreme or unexpected forces without collapsing.

While the key is to design a safe, cost-effective bridge while considering these concepts, owners often struggle with balancing these demands with their always-limited resources. A tool to assist in this process is included in the *Framework for Improving Resilience of Bridge Design*. The framework includes a fault-tree methodology that can be used to consider failure analysis during the design process. A portion of a fault tree for a typical girder bridge is included in the figure on the opposite page.

What's Next?

As bridge designers and owners continue to consider economy, ecology, and society in their designs, more long-term planning and design for resilience is the next logical step. First and long-term costs are already computed for most designs, and ecological and societal impacts are largely considered during initial design and construction. Future bridge designs must also consider the long-term impact to the environment and society through increased resilience.

References

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